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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the Scientific Literature) may prove of value to American scientists by calling attention to current developments and to institutions and individuals engaged in these scientific efforts.

The articles are written primarily by members of the staff of ONRL and occasionally articles are prepared by, or in cooperation with members of the

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BEHAVIORAL SCIENCES

AMPHETAMINES, BARBITURATES, AND INFORMATION PROCESSING

Stimulant drugs might be expected to improve performance, while depressant drugs should slow and otherwise degrade performance. In addition to clinical research on the effects of various drugs, there are many well-documented accounts of how drugs affect the performance of people engaged in such activities as track and field athletics, driving vehicles, and flying aircraft simulators. Few studies, however, have tied drug effects to specific stages of the underlying performance processes. A research program at the Institute of Perception, TNO (Dutch Institute For Applied Scientific Research) Soesterberg, The Netherlands, has been exploring such issues for some years now, and the results give a fairly clear picture of at least one drug-effects model. In the 1970s, the principal TNO researchers in this program were Don Trumbo, Andries Sanders, and Tony Gaillard; more recently, much of the drugs-and-performance work has been under the direction of H.W. Frowein.

From a practical standpoint, drug influence can be considered as belonging to a class of conditions that impose changes on the human organism. Noise, fatigue, and boring work can lead to performance decrements as can drugs. On the positive side, pleasant conditions, personal challenge, and interesting tasks can engage a worker and lead to high levels of effort and output, and some drugs seem to energize people in superficially similar ways. To interpret such phenomena, concepts such as arousal and attention may be invoked, but general conceptions of arousal or motivation do not help much to explain process details. Take the case of noise and the solution of arithmetic problems, where subjects first have to learn six-digit numbers and then mentally subtract four-digit numbers from them. Bursts of 100 db noise unquestionably affect performance of the task, but some parts of the task are affected more than others (the individual is much more susceptible to noise while learning the numbers than during the mental subtraction process itself). A principal job for the psychologist, then, is to identify the performance stages and to relate them to the action of experimental variables such as drugs, information load, and stress.

The TNO researchers adopted Saul Sternberg's (Bell Labs, Murray Hill, NJ) additive-factor model for reaction time as their drug-effects methodology. Sternberg originally proposed his model in the short-term memory domain. Typically, subjects are presented with a set of items and asked to hold them in memory; during a recognition test a second series of items is presented, and the subject is asked whether each item was in the original set or not. For such a situation, Sternberg postulated four processes or subtasks: (1) stimulus encoding, (2) comparison (with the stored set of items), (3) decision (yes or no), (4) execution of the response (e.g., pressing a key). The four stages seem plausible enough, but Sternberg's key insight was that a particular stage could be confirmed empirically by finding an experimental variable that affected only a postulated stage and did not interact with other stages. An example: for the first or encoding stage, legibility is such a variable; making the test word fuzzy or faint will cause a general rise in reaction time, but there is no statistical interaction between the action of this variable and the effects of variables that are hypothesized to influence other stages (such as size of positive set in the second or comparison stage). Thus, the concept of an encoding stage process gains in credibility. If two variables do interact, the Sternberg model would suggest that they are likely to affect at least one common processing stage; the stage so affected might be deduced from the nature of the interacting variables themselves. The procedure, then, is to explore the statistical dependencies between drugs and appropriate task variables within a postulated stage framework. With at least one effective and plausible task variable per stage, the method should indicate the stages at which the drug effects are having an appreciable impact on performance, and just as important, when they are having no such impact.

In the drug effects domain, the TNO workers had some previous indications that an additive-factor approach might work. It was known, for instance, that moderate doses of alcohol have a much greater impact on the response-selection stage than they have on either the earlier perceptual or the later response-execution segments of the process. In fact, alcohol and task variables were sometimes almost strictly additive, indicating they affected different processes, while at other times they were interactive, suggesting a common underlying process.

TNO hypothesized seven reaction-time (RT) stages and one movement-time (MT) process; they are shown with the task variables in Figure 1. On the input side, other research had suggested that preprocessing, encoding, and identification were logically separable and that intensity, degradation, and similarity were good candidates as task variables because they had been found to be additive with task characteristics of (logically) later stages in the processing. In the literature, there was also definite evidence that stimulus-response (S-R) compatibility was additive with changes in degradation, similarity, and muscle tension. In the motor part of the process, at least some of the task variables postulated in the figure are known to be additive; time uncertainty is additive with stimulus intensity, degradation, and S-R compatibility. Some of the other task

variables have not been shown definitely to be additive but can be justified for present use.

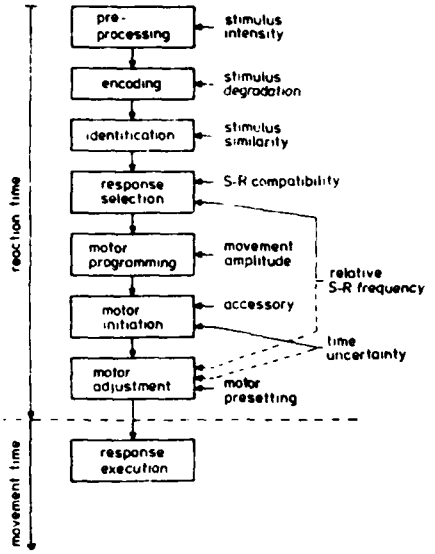

Fig. 1 Task variables and inferred stages in the reaction process.

The two drugs used in most of the TNO work were phentermine HCL as the stimulant, and pentobarbital Na as the depressant. When administered by rectal suppository, concentrations of these drugs are maintained at a fairly constant plasma level for some hours. Phentermine is one of the class of amphetamine derivatives that have been used as diet aids; doses of 20 to 40 mg were given in the TNO work. At such low dosages, the subjective effects of amphetamines often are increased alertness and feelings of energy; rather surprisingly, the drug has a calming effect on some people and has often been prescribed for hyperactive children. Externally observed symptoms of amphetamine may include pupil dilation, higher-than-normal blood pressure, and more variable heart rate; EEG tracings may exhibit more fast activity under amphetamine regimens than under normal conditions. At the performance level, many athletic scores can be expected to show increases from amphetamine dosages in the 20-mg range: swimming, shot put, grip strength, and bicycle ergometer. Small doses can also reduce or eliminate the usual time-on-task decline in continuous tracking. Physiologically, amphetamines can accentuate the release of both norepinephrine and dopamine at the presynaptic terminal.

The pentobarbital dose was usually 100 mg; in non-fatigued subjects this amount would be expected to have a mildly sedative effect. Such a dose should lead to lower EEG frequencies too, but there probably would be no depressant effects on heart rate. (Animal studies indicate that lower doses of barbiturate affect higher cortical structures but do not interfere with subcortical centers controlling basic bodily processes.) On a strict performance basis, barbiturate can impair many task scores: judgment of distance, eye movements, Stroop color naming, visual flicker fusion, and mental arithmetic. The results on simple reaction time are rather equivocal, although it can be said that barbiturates do not automatically cause longer response times.

A summary of one typical TNO experiment will give some feeling for the research. The subject faced a four-choice stimulus board on which there were a release button and four target buttons. The index finger of the subject's preferred hand rested on the release button. An imperative signal or action signal always indicated which target button was to be pressed (lower right in Fig. 2); one second before the imperative signal, there was a warning signal. The general instructions to subjects and also the bonus payment scheme emphasized that fast but accurate responses were desired.

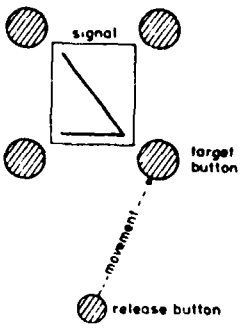

Fig. 2 Schematic representation of the stimulus situation.

Reaction time (RT) was automatically scored as the time between onset of the imperative signal and lifting the release button, while movement time (MT) was the interval between the instant of leaving the release button and activating one of the target buttons on the four corners. Task variables were S-R compatibility and stimulus degradation. A compatible response was one in which the "arrow" pointed to the target button; to make a correct and incompatible response, the subject had to activate the next button, that was counterclockwise to the arrow. Degradation was controlled by the application of a photonegative noise over the Nixie display tubes. Both placebo and drug suppositories were used, with a Latin square experimental design for controlling order-of-treatment conditions.

Errors and omissions by the subjects were rare, with overall error rates below 1%. There were strong main effects of S-R compatibility and degradation but no appreciable interaction between these task variables. Barbiturate-vs-placebo showed a main effect and a significant interaction with stimulus degradation.

Amphetamine, on the other hand, had a significant interaction with S-R compatibility: when compatible conditions obtain, amphetamine RT values are nearly the same as placebo RT values, but when the incompatible situation is imposed, amphetamine reactions are slower.

As to movement times, amphetamine produced the fastest responses, while the subjects operating under barbiturate displayed scores that were not greatly different from the placebos. No interactions between task variables and drugs were observed on the MT measure.

The results are clear; the additive nature of the task variables indicates that encoding, response selection, and response execution are independent processing stages. Amphetamine speeds up movement time, and it has an inhibitory effect if the S-R relations are incompatible or unnatural. In contrast, barbiturate slows down encoding at the front end of the performance but has no reliable effect, at the levels used in the tests, on response selection and execution.

The preceding experiment is only one of many drug-effects studies at TNO. When the whole series is considered, it seems clear that amphetamine shortens movement time; furthermore, it does this without influencing the efficiency of visual feedback. As to reaction time, amphetamine can affect the motor-adjustment phase and possibly motor initiation as well.

Low-dose barbiturate seems to have its main effects on stimulus encoding; phases such as memory comparison and response execution are nearly independent of barbiturate ingestion. Also, there are several suggestions from EEG data that both stimulant and depressant drugs can influence evoked potentials; the pattern of results is less clearcut than those using RT; perhaps the EEG measurements themselves are less reliable.

The TNO work should have implications for some current theoretical positions on arousal and attention. The stage-selective effects of amphetamine and barbiturate, for example, argue against a simple unidimensional concept of arousal. The stage analysis indicates that barbiturate has as its main consequence a near-automatic encoding process; indeed, this encoding may not require "attention" in the usual sense. In the Pribham-McGuiness three-system model for controlling attention, there is an orientation or arousal system, a response-readiness preparatory system, and a third system for coordinating activity; the last system requires effort. The TNO results with amphetamine indicate that a stimulant drug might affect the first two of these systems, but not the effort system. Low-dose barbiturates, however, may not influence either of the three systems postulated; rather, the depressant effects take place in the near-automatic and near-effortless encoding stage.

Nicholas A. Bond, Jr.

ONR London

PERCEPTION OF COLLISION IN NIGHTTIME DRIVING

Suppose you are driving in total darkness on road A, with no substantial background cues from the environment except for the road surface right in front of you. Suppose further that you see the lights of an opposing vehicle and that the opposing vehicle is on a straight road B that extends at an angle ϕ from your road and meets your road at an intersection. How do you estimate the likelihood of collision? According to studies by W.H. Janssen and A.R.A. vander Horst at the Institute for Perception - TNO (Dutch Institute For Applied Scientific Research, The Netherlands), there are only two cues that can be used to judge the likelihood of collision.

One cue is the appearance of the headlamps of the opposing vehicle; changes in the angle between the lights or in their brightness and size conceivably could provide relative motion information. The other cue is the bearing angle of the opposing vehicle's general illumination; a constant bearing angle of the other vehicle's lights relative to the straight-ahead path of your own vehicle is indicative of collision. Figure 1 shows the geometry in a simplified straight-road situation; and represent velocities, and are distances.

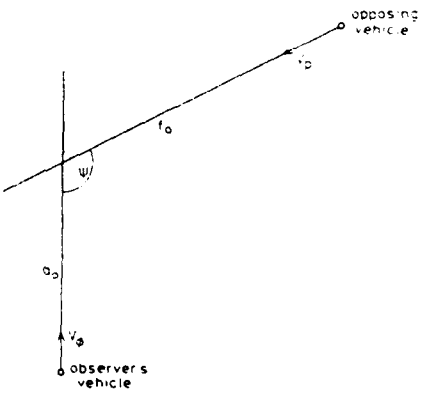

Fig. 1 Geometry of the possible collision configuration.

If $\frac{a_o}{v_\phi} = \frac{f_o}{v_p}$, collision will occur, otherwise, not. To use the (possibly changing) angle δ between the opposing vehicle's headlights as a

collision cue, a driver would have to discriminate "collision values" of δ from noncollision values of that parameter. The value of δ changes over time as follows:

$$t_{\delta} \; \delta_t = \frac{d(f_t - a_t \cos\psi)}{a^2{}_t + f^2{}_t - 2a_t f_t \cos\psi}$$

A human driver usually cannot discriminate collision values of δ until collision is imminent. This can be seen in a sample potential collision, worked out by the TNO investigators, illustrated in the figure below. (For the illustration, the two velocities and two distances from the intersection are assumed equal, pointing to a collision in 15 sec.) Figure 2 shows δ values and bearing angles as functions of time. Until 7 or 8 sec after the episode begins, the δ curve for collision is the same as that for noncollision, so use of the δ parameter would be impossible during that interval; even after that time, the task is extremely difficult, as the curves do not rapidly diverge.

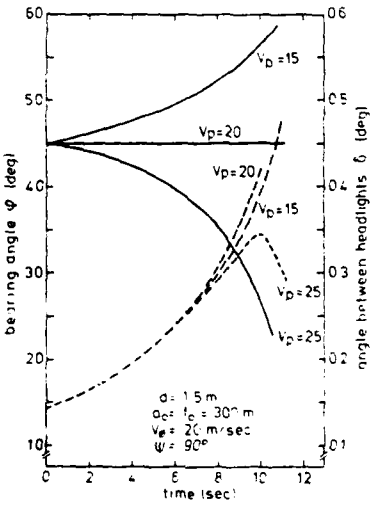

Fig. 2 Plots of δ (dotted lines) and ϕ (solid lines) against time for a given configuration.

The perceptible change in bearing angle, however, is a very powerful cue; from time zero on the graph above, the predictive and discriminative power of bearing angle is evident, with rapid divergence between curves. If the bearing angle is constant (45° in this illustration), collision will ensue; otherwise there will be no collision. Furthermore, an increasing bearing angle means that one's own vehicle will arrive at the intersection first; a decreasing angle means the opposing vehicle will get there first.

TNO studies have determined human performance parameters regarding bearing angle when speed and time conditions are varied. A Volvo sedan driving simulator with a split projection screen was used; half of the trials resulted in collision and half did not, and the subjects had to make predictive judgments of the outcomes under near-threshold conditions. A significant difference between stimulus exposure durations of 1 and 2 sec was observed; if the initial bearing angle is relatively large, then the threshold of angular movement is lower, at least for such brief exposures. An artificial parameter, the "detectable time gap," was derived from the simulator performance data; the gap is the just-perceptible time interval between arrivals of the two vehicles at the intersection point. Gaps on the order of 2 or 3 sec are easily detectable by the observer and can go below 1 sec if conditions are favorable. This finding, as well as the other threshold data, shows the remarkable sensitivity of the human observer to bearing angle information.

Ship and aircraft operators are often taught to use bearing angle as a direct collision cue. To close on a distant friendly aircraft and to position one's own plane on the wing of the other aircraft, student pilots are often advised to "fly the other plane" to an imaginary spot on their own windscreens; this maneuver will result in eventual closure of the two aircraft. The bearing angle cue, however, is rarely taught to road vehicle students. The TNO work suggests that it might be explicitly included in ordinary driver-training programs. For perceiving collision of special vehicles or unusual paths, much more psychophysics needs to be done before human prediction of collision can itself be accurately predicted.

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PREDICTING HUMAN PERFORMANCE IN A NEW SYSTEM

When a new system in which people will play an important part is being designed, it is necessary to estimate how well, how fast, or how reliably they will work in the new situation. Judging from present practice, there are only a few ways to go about making such estimates. One is simply to extrapolate from past experience with similar systems. While it is often hard to say just how similar one system is to another, there are rule-of-thumb numbers that have proved to be fairly reliable over the years. In military electronics, for example, research in the past 30 years has shown that the median time to troubleshoot a moderately complex piece of equipment is about 1 hour. This has held true over hundreds of items of

military equipment, from vacuum-tube radars to miniaturized airborne computers; so, if a new radar is introduced, the analyst might well assume that it will take about an hour for a single fault to be identified and located. Straightforward extrapolation can fail, however. If an item is radically modularized, trouble-shooting down to a module may be quite straightforward and rapid. To take a current example, if the advances now being made in fault-tolerant circuit design are realized, no time will be required to find certain troubles because the equipment will adjust itself instantly to some faults, and in those cases the user will never know a fault occurred. Another difficulty with simple extrapolation is that overall performance figures from the past may largely be due to non-system factors such as administrative routine and delay, so such experience figures are of limited use to system planners and evaluators.

A second way to predict is to construct a simulation of the new system. This can be either a full-scale semimanual imitation of the final system or a plywood mockup; in any case, the people who will operate the system are made to go through their task routines, time and practice curves are taken, and the whole thing goes through successive waves of shakedown and refinement. Simulation has been used successfully in the great NASA projects, in Air Force surveillance centers, and in many command, control, communication (C^3) and air control evaluations. Perhaps the main practical difficulty with simulation is the expense involved. There are also unsolved technical problems as to the degree of fidelity required, how much practice should be given, and how to handle team problems. Realistic simulation efforts often turn out to be major headaches for the system designer and user, and there can also be conflicts revolving around the freezing and modification of design features as a result of simulation runs. Simulation efforts are not always well funded in big-system contracts. Often, by the time simulation can start, there is insufficient money to do a satisfactory job.

A third approach to performance prediction, and perhaps the most appealing on scientific grounds, is the separation of human work into basic or component activities. Every work activity has specific time and reliability characteristics, and these can be expressed in compact form by means of statistical distributions. The parameters of the distributions can be determined empirically, or they can be taken from previous tabulations in handbooks and journals. For a new system, once the human activities are well defined, many separate activity or task distributions can be assembled and summed in a computer, and the overall time to complete the activities can be estimated, along with probability of success. The numbers can then be inserted into the usual system-effectiveness equations. Supplementary analyses of one kind or another can be run; for example, at the points where a behavioral summation suggests that protracted or unreliable performance will occur, the system designer can consider changes to improve the prediction of the particular task segments. Special graphic and numerical techniques exist for identifying the hard spots in a prospective system.

Microanalysis of behavior can be effective, and it can yield accurate human behavior predictions. Decades of motion-study applications have demonstrated the usefulness of time summation in repetitive industrial work. Arthur Siegel (Applied Research Associates, US) demonstrated some years ago that the technique can be extended to such complex activities as carrier landings of jet aircraft; the outcome probabilities from his computerized task syntheses closely resembled those found in the real world. Alan Swain and his colleagues at Sandia Laboratories (US) have been using task-probability synthesis in their work with nuclear-weapons test and assembly. In what must be one of the most precise determinations of human performance parameters ever achieved, Thomas Trabasso (US) some years ago studied the timing of logical processes in a single well-practiced subject. He found that a certain basic inference took about 630 ms, and that added complexity, such as increasing the numbers of logical transformations, increased the time regularly. Some of the comparisons suggested that each additional transformation requires about 1/10 sec. More recently, Robert Sternberg (Yale Univ., US) and others have extended the chronometric approach into quite powerful explanatory models of three-term syllogistic reasoning.

There are still many problems in applying task-time synthesis to practical systems work. The first is the question of which task classification to use. Then there is the question of the data base available: does the literature really list the times and likelihoods of error of all the activities of interest? Statistical summation schemes usually assume independence and simple combination of times and errors, assumptions that are certainly wrong at times. With all the difficulties, it is interesting to note an attempt to apply the model in a big-systems domain; we summarize here an excellent British example. The research was originated by the Applied Psychology Unit in the Admiralty Marine Technology Establishment (AMTE) at Teddington, England. Much of the data bank was assembled and task breakdown was by EMI Electronics at Feltham, England, under an AMTE contract, with Dabid Rumeas as investigator. Validation experiments of the prediction system were by Michael Tainsh and his colleagues at AMTE Teddington.

From the beginning, it was anticipated that the method might be used for future submarine systems and that such systems would be semi-automated, computer-aided, and involve much data entry, updating, and deletion. The investigators therefore adopted a format that emphasized the interaction of people with

specified input-output devices. The EMI researchers tabulated the available man-machine data into activity-device matrices (ADMs). The ADMs summarized performance time and error figures insofar as they could be gleaned from the literature up to about 1978. Eighteen input devices and 13 output devices were included, and there were over a dozen behavior categories. The figures below show fragments from the input and output device time matrices; although for purposes of this brief report we do not present full definitions of each row and column, perhaps enough detail appears to give some flavor of the system.

The matrix excerpts show two things. First, there are many gaps in the coverage; time data were simply not available for about half of the matrix entries. Likelihood-of-error matrices were even more sparse, with error frequencies being estimated for less than half of the matrix cells. Locating the gaps in the tables can be useful; the gaps indicate places where the handbook values are missing and where research needs to be done. In a practical prediction project, the gaps might also suggest places where a simulation could be undertaken to get data. For such reasons, the EMI team also tabulated "gap overlay" for each time and error matrix.

ACTIVITY-DEVICE MATRIX ESTIMATED TIMES

INPUT (Secs)	Selection (Device)	Actrition (Device)	Do-Selection (Device)	Positioning		Tracking	Control Action		Sele
				Static (Items)	Moving (Items)		Discrete (Items)	Continuous (Items)	
	a	b	c	d	e	f	g	h	
	.49	.5	.43	4.5	5.5	50	.9	4.5	
	.38	.5	.29	3.1	4.6	39	1.25	3.5	
	.8	.6	.38	4.4	5.3	43	1.5	5.0	
	.47	.6	.38	4.5	5.9	59	2.5		
	1.39	.3	.58	5.5					
	1.17	.35	.31	4.8	7.0	60			
	1.91	.5	1.74	2.25	3.0				
	1.2	.27	.63	7.0					
	1.33	.3	.63	4.5					
	.58	.35	.82	3.0	5				
	.58	.35	.82	3.					
	1.13	.8	.43						
	1.26	.9							

OUTPUT (Secs)	Selection (Device)	Detection				Appreciation			
		Signal	Pictorial	Graphical	Tabular	Signal	Pictorial	Graphical	Tabular
	a	n	o	p	q	r	s	t	u
	.48				.25				.59
	.48	4.7			.2	7.9			.9
	.48	5.0	12.1	.36	.2	5.0	1.5	.7	.6
	.48	1.0			.23	.5		.6	.54
	.48				.23	8.0	3.0	.7	.8
	0	.99			3.0				
	.24							.5	
	.48				.24				
	.48						1.0		
	.48			.2					

A second obvious feature of the ADMS is that most of the activities take just a few seconds to complete. In the application undertaken at AMTE, this was because main decision-making tasks in the new system were excluded from the analysis; for the jobs concerned, it was postulated that decisions would be made at higher command levels. Such a limitation seems reasonable enough in the submarine context and it sidesteps some tough measurement issues, but it might be a problem in other system prediction efforts.

The AMTE and EMI researchers saw that the output of the task synthesis might be used in at least two ways. The first was to evaluate alternative equipment configurations, such as arrays of input-output devices. For example, Tainsh at AMTE analyzed the results of injecting a single new item into the system by means of light pens, pushbuttons, and rollballs. All new computer-aided systems have such a data entry requirement. There are several ways this can be done, and although the differences between the summed times and error likelihoods turned out to be minor, the attempt showed that such evaluations can be carried out (the rollball procedure was slightly better than the light pen in one procedure-device combination). Viewing the particular results, a designer might well look at the marginal differences and choose an equipment-procedure combination on secondary grounds such as cost, cosmetic appeal, or preference of the operators.

For a larger experimental trial at AMTE, Tainsh used four longer chains of activities; these had 30, 52, 50, and 91 activities each. The subjects had operated similar equipment before, so they were perhaps a more appropriate sample than the usual naive college subjects. Each subject performed each behavior chain three times; all performance attempts were videotaped to confirm the scoring of errors and times. The main hypothesis was that the observed times for real people carrying out the task chains would be very close to those predicted by the summation model. A supplementary hypothesis was that accuracy of prediction would be independent of task-chain length; that is, the error would not cumulate as behavior sequences get longer but would vary around zero.

In a great majority of cases, real performances were considerably faster than predicted by the model. Errors of prediction were highly correlated with task length, as can be seen in the following table:

Procedure	Number of Activities	Model Predicted Time	Mean Actual Time	Disparity
A	30	25.6 sec	18.49	27.6
B	52	46.8 sec	30.47	34.8
C	50	45.4 sec	25.07	44.8
D	91	81.0 sec	40.86	49.5

It appears that the task synthesis model overestimated actual times by some 25 to 50%. A gross conclusion is that, for long task sequences, one cannot expect great accuracy of prediction from a simple summation model. The accuracy can be improved by statistical correction of the model values. For example, the following regression equation fits Tainsh's data closely:

$$t_{actual} = 0.4\ t_{model(sec)} + 8.78$$

There is no reason, however, to believe that the constants in the equation have any general validity or that the relation between predicted and obtained times would be strictly linear in a new setting. Certainly the 8.78 time intercept does not appear to reflect any natural parameter.

The attitude of AMTE investigators toward task-synthesis methodology has changed. As noted above, the experimental comparisons did not support the idea of absolute time predictions. But it often turned out that an overall time accurate to within about 50% was still useful and probability-of-success numbers were often very high. So the method is clearly able to rank order the performance potentials of various man-machine combinations. Thus, it can be valuable for rough estimates and can often yield some reassurance to system designers that behavior specifications are within reasonable ranges.

Perhaps the most salutary lessons from the task synthesis application are those that have to do with the task analysis. Activities that logically appear as separate items in a task list may not really be separate when a human operator performs the task. It is therefore always worthwhile to validate the presumed set of tasks and to see how the operators actually do the work. When predicted and obtained times are really quite disparate, going back to the actual work often explicates the disparities. At some point the procedures can be smoothed out about as well as is possible; by the time that has happened, supervision, motivation, and other factors may outweigh and outdate the original analysis.

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COMPUTER SCIENCES

A NEW SOFTWARE TECHNOLOGY INITIATIVE AT THE UK SCIENCE AND ENGINEERING RESEARCH COUNCIL

The term "software engineering" was the title of a NATO conference held at Garmisch, West Germany in October, 1968. According to the conference report, the phrase was "deliberately chosen as being provocative in implying the need for software manufacture to be based on the types of theoretical foundations and practical disciplines that are traditional in the established branches of engineering." Provocative indeed! The phrase caught on across the

Atlantic and spread westward like a prairie fire. Fourteen years later, despite the bandwagon effect we have witnessed in the US and Europe, we still need a wide range of practical disciplines and theoretical foundations for software development. But worst of all, a new discipline (or cult) has been born (with its own jargon) consisting of self-proclaimed software engineers, baroque software engineering facilities, new bureaucratic software engineering R&D initiatives, and numerous worldwide software engineering conferences. The community is still busily seeking to model its activities after the established branches of engineering as intended by the original NATO conference in 1968. Perhaps the cure for lack of disciplines and theoretical foundations became in itself a branch of computing science without disciplines and theoretical foundations. In view of the current state of confusion about software technology, which the UK Science and Engineering Council (SERC) terms a software crisis ever increasing in seriousness and economic and industrial importance, a panel was formed by SERC's computing and communication subcommittee (CCSC) to review the situation. The panel reported in October 1981: "Already the cost of software is frequently greater than that of the associated hardware, and this trend will be accentuated by the continued reduction in hardware (silicon) costs. Software production must be one of the few industries where no adequate tools exist for specification, design, production updating, and re-engineering. Despite the high cost and long development cycle of most large systems, no serious attempt is being made to develop new software methods and standards which could reduce both cost and time scale. Add to that the need for improved hardware independence and more user-orientated approaches to high-level language support. The panel is aware that the computing science committee has devoted significant funding to this area but considers that more should be done, particularly in exploiting existing research and applying this in industry. As with silicon chip design, there may be a need for a mechanism to bring universities, software houses, and industry together and maximize the benefit of academic research, taking full account of the major contribution industry is able to make in this area."

In November 1981, CCSC acted upon the recommendation and launched a software technology initiative with three major objectives: stimulating more high quality software engineering research; improving the academic software technology base; and facilitating two-way technology transfer between industry and academia. The initiative is modeled after SERC's highly successful Distributed Computing System program described in ESN 35-8:298 (1981). The same "management by peer judgment" approach will be used, and SERC's Rutherford & Appleton Laboratories will administer the new program. In fact, Dr. R.W. Witty of RAL, who was the academic coordinator of the DCS program, will be the coordinator of the Software Technology Management Panel. In November 1981 a letter of solicitation was sent to all relevant academic and industrial parties with a press release outlining CCSC's concerns, priorities, and common base policy. This enabled applications and proposals for grants to be generated before the end of 1981 with the aim of starting the program in April 1982. The new initiative will be closely bounded as DCS is in both time and money. It will be an ad-hoc 5-year effort with a planned budget of £2.5 million ($5M). An annual report will be published, and CCSC will review its policy on software engineering annually so as to remain flexible in the light of future events and developments. A bimonthly progress "mailshot" (newsletter) will go to both academic and industrial parties to provide visibility and to eliminate unnecessary duplication of efforts.

Common Base Policy

The entire academic community, not just computing science, is a major user and developer of software. The academic software technology base lacks uniformity in the UK, as it does everywhere, in that knowledge, experience, tools, techniques, and equipment vary widely among research projects. CCSC felt that a common hardware and software base was essential to bring all of the existing tools and techniques into a uniform framework. This is to be achieved via extramural research contracts to move existing tools into the common base. A good case in point is the widespread use of UNIX (an operating system developed by the Bell Laboratories) that has enabled a large number of software tools to be made available throughout the UK academic community. This common base policy will relate to all SERC-supported research, thereby giving the new software technology initiative the maximum opportunity to improve the quality of software available to all UK research scientists.

SERC wants the common software base to be Pascal/UNIX and the common hardware base to be PERQ. PERQ is a personal computer workstation with graphics capability manufactured by International Computer Ltd. in the UK under license from Three Rivers Computer Corporation, Pittsburgh, Pennsylvania. Some of PERQ's major components are: (1) 10^6 instructions per second 16-bit CPU; (2) A4 page-size 1024x768 pixel display; (3) keyboard and 2-D magnetostrictive graphics tablet for man-machine interface; (4) 24-M byte Winchester disk and 8" floppy disks for local file store; (5) 10 Mbit/sec Cambridge Ring local area network interface and standard RS-232C and IEEE 488 communication interfaces. PERQs will be networked via Cambridge Rings, SRCnet (the SERC network) in conjunction with the Interactive Computer Facility (See ESN 36-1:7 [1982]) and packet switch systems to allow wide cooperation between users and developers.

All PERQs will be purchased by SERC. PERQs running Pascal programs under the control of UNIX will be loaned to participating institutions on their undertaking to develop or transfer tools to the common base and distribute the software tools to the community via Rutherford & Appleton Laboratories, which will act as the central clearing house and will award extramural research contracts for promising tools to be developed and brought into the common base. For tools that cannot be brought into the common base such as big, machine-dependent theorem-prover and circuit-design packages, accesses via network facilities will be arranged.

In short, SERC has decided on a strategy of creating a common hardware and software base for software development in all SERC-sponsored research areas using Pascal and Fortran (user programs, not tools) on PERQs linked locally by Cambridge Ring and nationally by wide-area network systems conforming with international standard X25 protocols such as SRCnet and packed switch systems. To date, Distributed Computing System programs, the Interactive Computer Facility, and the Software Technology Initiative have had funds approved to purchase PERQs as the first step to launch the common base policy. This is the way SERC will provide computing resources to all scientists, not just computer scientists.

Research Priorities

The common base policy is expected to improve the near-term software efficiency in the UK by reducing duplicate production of software tools and training needs and increasing the quality of such tools and their availability to scientists. In addition, CCSC will fund new projects that are likely to lead to significant advanced techniques to meet the software crisis. After several meetings with academic and industrial experts, a letter soliciting views was circulated. As a result, CCSC identified the following list of research priorities and solicited software technology research proposals on: (1) program specification, (2) verification techniques (manual and automatic), (3) pure theory (formal logic, semantics, etc.), (4) application theory, (5) programmming workbenches, (6) specific problems (security, reliability, etc.). Proposals were received in January 1982. CCSC is now evaluating the proposals for research grants to start the program in April.

Academic Technology Base

With the common base policy established, CCSC has adopted a plan to improve the academic software technology base. The plan contains the following objectives: "(1) identifying the software-tool and technique-producing people and projects; (2) forming them into a working community by person-to-person links, computer-to-computer links, and common software and hardware base policies; (3) setting in motion a coherent plan to exploit the software tool production by making such tools and techniques widely known and available in forms that can be used readily by the entire user community." CCSC is implementing the plan by taking the following steps: "(1) collecting information on the range of current SERC projects making software tools, (2) identifying the whole community concerned with making tools, (3) listing the actual tools currently in use and found worthwhile, (4) identifying software tools that are seen as needed, (5) identifying potential tools (starting an open-ended list, actually a working paper), and (6) updating the paper on a regular basis." CCSC is also forming a working community and circulating by 'mailshot' within the community to solicit improvements of the working paper. The software engineering community will be linked through the computer network provided by the common base.

Technology Transfer

CCSC recognized that technology transfer needs to be stimulated by the funding bodies and that technology transfer is a symmetrical two-way process between industry and academia. To achieve this, CCSC intends to set up software technology centers to serve as focal points for several areas of interest. CCSC also appointed an SERC software technology coordinator at Rutherford & Appleton Laboratories to oversee the implementation of the plans, to stimulate research proposals, and to act as SERC liaison with other funding organizations and industry. In this way, it is hoped that the British academic community will be drawn into close and profitable association with British industry for better software engineering practices.

Summary

The software engineering bandwagon in the 1970s could be viewed as a software cultural revolution. After the "thousand flowers bloom" phase during which unformed plans and ideas were rife, more pragmatic and better organized research initiatives were inevitable. It appears that the UK's SERC has taken steps in this direction. The plan as outlined above is well conceived in the same style as the successful Distributed Computing System program. Austere funding will subtly enforce the common base policy. It will provide program visibility and eliminate duplication of effort. As a consequence, better selectivity and better research will be ensured. At present, the US Department of Defense and the US Navy are contemplating new research initiatives for software technology and the development of software engineering environments. In the writer's opinion, DoD and the Navy planners would be

well advised to take note of SERC's experience and monitor closely the progress in the UK.

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MATERIAL SCIENCES

ACOUSTIC EMISSION FROM PAINT FILMS

It is generally accepted that paint must adhere firmly to underlying surfaces to protect them effectively from weathering and corrosion. Thus, adhesion tests are important in the development and testing of new paints and painting processes, and a number of physical adhesion tests have been devised by the paint industry. While such tests give an idea of overall adhesion quality, they are less useful for providing information on specific mechanisms of adhesive failure and the factors influencing debonding. That is why new methods for testing paint adhesion are constantly being sought and assessed. One promising technique, involving ac impedance measurements, is being used by a number of investigators studying the character and behavior of paint films (see ESN 36-1:12 [1982]). Another new technique, which relies on analyses of acoustic emissions during tensile testing of painted panels to determine paint-film quality, is being assessed by at least two groups, one at the University of Duisberg, FRG (see, for example, papers by H. Hansmann and H.G. Moslé in Proceedings 8th International Congress on Metallic Corrosion, Mainz, West Germany, 1981) and the other at Imperial College, London. Recently, the work of the Imperial College group was outlined for the author by Dr. R.D. Rawlings of the Department of Metallurgy and Material Sciences.

Rawlings and his colleagues have been using acoustic emission techniques for several years in studies of microstructure-property relationships in ceramic materials. In particular, they have used the technique to monitor subcritical crack growth during fracture toughness testing of alumina and alumina-zirconia composites and in the characterization of high quality alumina for hip prostheses. The research, along with acoustic emission studies of painted surfaces, is continuing.

For paint film research, steel panels are prepared by various methods and are coated with paints of interest. The coated panels are then tensile tested to fracture in an Instron machine at a strain rate of 4×10^{-4} sec^{-1}. Acoustic emission during tensile testing is monitored by means of a clip type PZT transducer (150 kHz resonant frequency) attached to the panel midpoint. Through suitable electronics, the ringdown counts and event counts are measured as a function of strain and the amplitude distribution of events is obtained. So far, a typical automotive finish has been investigated. This has included tests of panels with the complete four-part automotive system including topcoat as well as panels with the individual components of the system, i.e., steel alone, phosphated steel, phosphated steel plus anodic electrocoat primer, and phosphated steel plus primer plus surfacer coating.

The tests showed that steel and phosphated steel had a single acoustic emission peak at tensile strains less than 10%, whereas phosphated panels with additional coats of primer, primer plus surfacer coat, or the complete four-part coating, exhibited two peaks, one below 10% and one above 30% strain. The peaks have been correlated with microscopic observations; thus, the low strain peak was identified as due to cracking of zinc phosphate crystals, debonding between the zinc phosphate layer and the mixed crystal (i.e., iron phosphate plus zinc phosphate) underlying layer, and microcracking of the upper primer and paint layers. The high strain peak was associated with gross visible cracking of the topmost paint films.

The amplitude distribution of acoustic events during a tensile test was deconvoluted through computer analysis by assuming that the distribution was due to several breakdown mechanisms, each with a specific energy (amplitude) and each of which could be approximated by a Lorentzian distribution peaked at a specific amplitude. As a result, four processes with peak amplitudes at 22, 26, 35, and 47 dB were identified. The peak at 22 dB was correlated with cracking of zinc phosphate crystals. Adhesive failure of the bond between the zinc phosphate layer and the mixed iron phosphate-zinc phosphate layer was correlated with the peak at 26 dB. The peaks at 35 and 47 dB were correlated with gross cracking and peeling of the upper paint layers.

The results of the foregoing research were obtained with paint films that had not been exposed to the environment. However, research is well in progress in which such tests are being carried out on films exposed to water. Rawlings feels that the acoustic emission approach will be equally informative in determining the adhesive characteristics of such films. Perhaps in the future, in place of speculation about how well paint films will adhere, the films themselves will tell us, if we listen carefully.

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ION PLATING AT SALFORD UNIVERSITY

The ion plating technique for coating surfaces was first described over 40 years ago, the term ion plating was coined about 20 years ago, but only fairly recently has the technique assumed a degree of commercial significance.

The ion plating process consists of several distinct steps, initiated by the striking of a glow discharge between the substrate to be coated and the grounded evaporation chamber in a partial vacuum. The substrate is usually held at negative potentials of the order of 2 to 5 kV and pressures of 10 to 50 millitorr of inert gas such as argon are typical. While the substrate is exposed to the glow discharge, its surface is energetically bombarded and cleaned by a sputtering process. Then coating material is evaporated into the glow discharge and the material, some of which is ionized in the discharge, is deposited on the substrate. An essential part of the process is that the evaporation be made during the glow discharge; coatings deposited after sputter cleaning but in the absence of the glow discharge lack good adhesion. When done properly, coatings produced by the process are noted for their good adhesion, which is usually better than that of coatings produced by other physical vapor deposition processes.

Recently the author visited Mr. Dennis G. Teer, reader in engineering at the University of Salford, to learn about activities there in ion plating research and development. Programs in ion plating, funded by the Ministry of Defence and by grants from the Science Research Council, have been in operation at Salford since 1970. About 6 years ago a grant from the Wolfson Foundation allowed the university to set up a company, Salford University Industrial Center, Ltd., to exploit the technological expertise of the university in ion plating. The company offers laboratory services, develops processes, makes equipment, and carries out small production runs. Although the company has not been notably successful to date for a number of reasons, Teer, who has been in charge since September 1981, said that business had improved markedly in recent months. Most work requests deal with coatings required for corrosion resistance or for tribological applications.

Teer has balanced his practical interests in ion plating nicely with a research program aimed at improving understanding of the process and the effects of process variables on coating structure and properties. For example, he has been concerned, as other researchers have, with explaining the enhanced adhesion of coatings produced by the process. Although an unequivocal explanation cannot be given, the consensus is that in addition to the sputter cleaning of the substance, good adhesion can be traced to the following factors: implantation of ions into the substrate lattice, enhanced diffusion of coating material into the substrate as a result of the high temperatures and substrate lattice defects produced by the impinging high-energy atoms and ions, and physical mixing of depositing atoms and sputtered substrate atoms that return to the substrate as a result of recoil processes with gas atoms. The last-named factor could be especially important in explaining the good adhesion between coatings and substrates of mutually insoluble materials.

A major part of Teer's research has been devoted to determining the effects of process variables on the structure of ion plated coatings. For this research he has used a thermionically assisted triode ion plating system shown schematically in Figure 1. The ionization efficiency of about 0.1% encountered in a

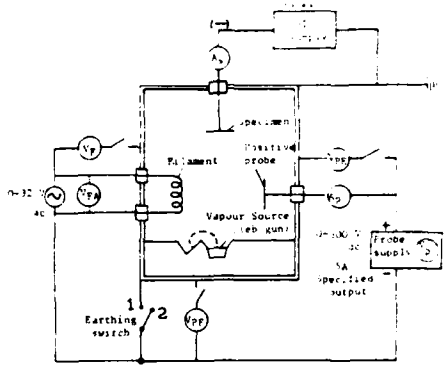

Fig. 1 Triode Ion Plating System.

diode system can be raised to over 3% with the triode arrangement. This allows the same specimen current to be obtained at much lower bias voltages, thereby reducing bulk specimen heating. It also allows gas pressures to be reduced to a millitorr or less while the glow discharge is maintained and the cleanliness of the coating operation is generally improved. With the triode system Teer has investigated the effects of variables such as bias voltage, specimen power density, and gas pressure on coating structure. Systems investigated were copper deposited on nickel and chromium on steel. He has found that the specimen power density is apparently the most important variable. At low power densities the coatings produced have nodular grains with weak grain boundaries. As the power density is increased, columnar growth occurs with dense boundaries. Finally, at sufficiently high power densities, very dense deposits with fine equiaxed grains, sometimes as small as 0.1 μm in diameter, are produced. Teer feels that the changes observed can be correlated with the rise in surface temperature and concomitant increase in diffusion rates as the power density is increased (although the overall bulk temperature can remain relatively low). The fine grain size noted at high power densities, he speculates, is the result of recrystallization from many nucleation centers produced by the ion bombardment.

plated surfaces. Typical of his efforts is a study of the friction and wear characteristics of Co and Co-Cr coatings on steel in which tribological characteristics are correlated with the crystal structure and preferred orientation of the coating (Thin Solid Films, 84 [1981] 281-288). More recently, however, he has been investigating reactive ion plated coatings. Such coatings are produced by admitting a small quantity of gas to the coating chamber during evaporation of the metal, thereby causing a reaction between the two species. Gases such as oxygen, hydrocarbons, and nitrogen are used to produce oxide, carbide, and nitride coatings. If the reactive gas flow is intermittent, layered metal and compound coatings can be produced. This not only gives materials that may have interesting properties, but it also tends to suppress less desirable columnar grain structures. Two types of reactive ion plated coatings, aluminum-aluminum oxide and titanium nitride, are currently being investigated. The motivation for the former, which is in the early stages, is to give better handling characteristics to aluminum plated fasteners and to reduce seizure if fasteners are removed. The plan is to harden the coating by incorporating a small amount (5 to 10%) of aluminum oxide without affecting the corrosion properties of the coating. The work on titanium nitride coatings is well advanced.

Titanium nitride (TiN) is an almost ideal compound for reactive ion plating. Titanium is easily vaporized and nitrogen is cheap, readily available, and simple to handle compared with other reactants such as hydrocarbons. With titanium nitride, deposition rates of about 1 μm/min are easily reached. Furthermore, the nitride is very hard (2700 Vickers microhardness for typical coatings), resists softening at elevated temperatures, and has good chemical stability. (An interesting added bonus of TiN coatings can be their pleasing yellow-gold color. In this regard, Teer recounted an amusing incident in which a manufacturer of contact lenses experienced reduced die breakage from handling since employing TiN-coated dies. He attributed this to the fact that his workers felt that the new gold-colored dies were much more expensive than the uncoated steel dies formerly used and were more careful when handling them.) A disadvantage of TiN coatings for wear applications is that they are limited to use on substrates that do not soften at the processing temperature, which may reach 500 to 600°C depending upon the heat sink conditions. Thus, the coatings are usually applied to high-speed tool steels.

For the most part, Teer's experience with TiN coatings has been confined to practical applications on metal-forming tools where the substrate is typically H13 steel hardened to about Rockwell C50. To evaluate the coatings and the coating process, a plane strain compression test on cold-rolled mild steel strip is carried out (Fig. 2) and coating wear is followed by observation in the scanning electron microscope. In this type of test it has been shown that the surface of uncoated hardened

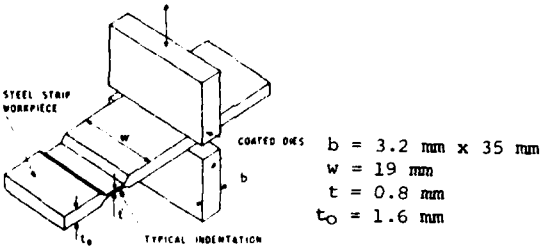

Fig. 2 The plane strain compression test.

H13 steel was severely scored after about 5,000 indentations. In comparison, the same material coated with only 2 μm of TiN showed no signs of wear even after 10,000 indentations.

A wide range of dies and tools are being TiN coated at Salford and evaluated in actual industrial operations. They range from small, simple drill bits to large (4-in high by 5-in diameter) multifaceted hobbing tools to be evaluated in gear cutting operations at Ford Motor Company; the latter required much experimentation before uniform, high-quality coatings were produced.

The potential for the ion plating coating process is obviously high, and Teer has a number of ideas he would like to pursue with the technique. Whether he will be able to continue the work at Salford is uncertain as his department is slated to lose 46% of its staff as a result of the recent government university cuts.

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TWENTIETH INTERNATIONAL CONFERENCE ON ACOUSTICS-ULTRASOUND

The Twentieth International Conference on Acoustics-Ultrasound was held in Prague, Czechoslovakia, from July 6 to 10, 1981. It was organized jointly by the Czechoslovak Committee of Electrical Engineers, the Czech Central Committee of the Electrical Engineering Society, the Acoustical Commission of the Czechoslovak Academy of Sciences, the Ultrasound Subcommission of the Acoustical Commission Section of Ultrasound in Biology and Medicine, the Czechoslovak Biological Society, Brno, and the House of Technology, Prague.

The conference was divided into four sessions: physics of ultrasound (19 lectures), engineering applications (18 lectures), high power ultrasonics and industrial processing (6 lectures), and medical applications (14 lectures). Although good work was reported in all the sessions, engineering applications, especially in the general field of nondestructive

testing, attracted the largest number of participants.

In his opening address, Prof. O. Taraba (House of Technology, Prague, Czechoslovakia), chairman of the organizing committee, pointed out that the distinction between applications of ultrasound and the physics of ultrasound sometimes is difficult to make and in many instances may be unnecessary. He said that in the future nonlinear effects will be considered more and more in ultrasonic wave generation, propagation and interaction, and monitoring and measuring. According to Taraba, further development of ultrasound will influence such activities as physics of the nonequilibrium state, low-temperature physics, and possibly phonon spectroscopy of solids, acoustic emission, etc. For example, he said it is reasonable to expect that development of acoustic emission techniques will allow us to extend ultrasonic spectroscopy when it is understood as an analogue to optical spectroscopy. Taraba also pointed out that the use of tetrahertz frequencies at low temperatures might pave the way to the phonon spectroscopy of solids. The generation of ultrasonic waves by intense light pulses already has made it possible to observe parametric phenomena as well as phonon echoes. The study of nonlinear phenomena offers promise of a new technique for physical diagnostics and may be important in understanding phase transitions.

There are many acoustical analogies of optical phenomena worthy of mention; two fields in particular, photoacoustic spectroscopy and acoustic microscopy, appear to be expanding considerably on the basis of such analogies. In addition to combined fields such as acousto-optics, one can observe the emergence of opto-electronics and acousto-electronics. In fact, many of the fields merge in experiments dealing with surface acoustic waves; with interdigital electrodes surface acoustic waves can be generated and studied by both optical and electronic probing.

The power applications of ultrasound have been successful in a number of areas. They include ultrasonic welding of copper and aluminum, ultrasonic cleaning (especially good for small machine parts, treating waste, processing animals or even minerals), and drawing of wires and thin-walled sections. Such successful applications ultimately require deep study of physical principles and the observation of such phenomena as cavitation, fatigue, stress-strain relationships, etc. In like manner, medical applications depend ultimately on thorough study of the fundamental physical principles.

In a conference the size of the one discussed here, it is impossible to attend all the lectures. For that reason, the following remarks represent a random selection of the papers presented. The sole purpose is to provide an impression of the range of topics covered primarily in physics and engineering.

Y. Gulyaev (Moscow Univ., USSR) opened the program on physical acoustics with a discussion of "Nonlinear Photoelasticity of Crystals and Interactions of Electromagnetic and Acoustic Waves Due to Nonlinear Photoelasticity" in which he pointed out that the propagation of the ultrasonic wave modulates most physical properties, including permittivity. If the energy of the ultrasonic wave is as great as the molecular energy level difference, then interaction can take place with the result that the ultrasound generates light that is collinear with it.

A. Sliwinsky (Univ. of Gdansk, Poland) discussed the diffraction of light by two adjacent ultrasonic beams in liquids. He compared the experimental results obtained in his laboratory with the theory of Leroy (Belgium) for $\rho << 1$ and varying parameters such as ultrasonic wave intensity, frequency ratio, and relative phase of the two ultrasonic beams; ratios of 1:2 and 1:4 were examined. In general, he concluded that the comparison between numerical calculations and experimental data is quite satisfactory.

Taraba showed that an acoustic emission occurs during application of an electrical or magnetic field to certain solids. A stochastic signal, which should be useful for the diagnosis of the structure of solids, is emitted during application of a magnetic field to a magnetic solid or an electric field to a dielectric solid. The signal, at approximately 450 kHz, has been found to be independent of sample size. Taraba played a recording of the signal, made as a steel sample was rotated in a magnetic field, over the loudspeaker. It was loud enough to be heard by all the participants and made a strong impression on the audience.

N. Kobelev and Y. Soifer (Academy of Sciences, Moscow, USSR) studied the effects of dislocations on ultrasonic attenuation in crystals of copper, lead, and alkali halides between 5 and 50 MHz. The dynamic-loss energy contribution to the total dislocation damping was measured and the viscous dislocation drag constant was determined to be between 4.2 and 300°K. The results were discussed in terms of models of phonon-dislocation and electron-dislocation interactions.

K. Bogdanova, V. Golenischev, and A. Monachov (Academy of Sciences, Kazan, USSR) described an "Acoustic Pulse Investigation of Spin Systems." The experiments were performed with $KMnF_3$ single crystals in a magnetic field at 4.2°K. Ultrasonic pulses, generated by a $LiNbO_3$ transducer bonded to one end of the sample, were detected by a second transducer at the opposite end. A double-pulse system was used at 650 MHz. After the propagation of the second ultrasonic pulse separated by 4.3 μsec from the first pulse, echo signals were observed. Simultaneously with the excitation of the echo pulse in the same magnetic field, strong absorption of the ultrasonic pulses was observed. From theoretical and experimental analyses one

concludes that the echo signals and the acoustic absorption were excited by spin transitions in the ^{55}Mn nuclei.

P. Hagedüs, S. Kolnik, and C. Musil (VSDS, Zilina, Czechoslovakia) discussed "Third-Order Elastic Constants and Invariance Relations." They pointed out that one must be careful in defining the adiabatic third-order (and higher-order) elastic constants to make sure that the mathematical expressions are rotationally invariant. The problem, which has been encountered before, is worth discussing because of its subtlety when one is trying to describe the nonlinear behavior of an anisotropic medium.

A treatment of "Ultrasonic Methods for Non-destructive Testing of Paper" by R. Kazys (Polytechnic Institute, Kaunas, USSR) revealed the value of excitation of Lamb waves in paper as it moves along during manufacture. The tensile strength L and the velocity of propagation v of the ultrasonic Lamb wave was found to be related by $L = av^2$, where the constant a depends on the direction of propagation of the Lamb waves. In the example presented by Kazys, the waves were traveling in the direction of motion of the paper during manufacture. Two types of ultrasonic Lamb wave generators were employed. (Piezoelectric transducers in air served as receivers in both cases, taking advantage of the improved radiation into air that occurs as the paper is bent over a roller.) The first transmitter was a piezoelectric transducer that produced a pulsed signal in the frequency range 40 to 80 kHz. The second was more intriguing, being a fixed steel ball that produced a signal by dry friction with the moving paper. As a result of the friction, a random signal with a normal low distribution was produced. The signal had a fairly uniform spectrum in the frequency range 30 to 150 kHz. The velocity of the ultrasound was determined by means of a correlation technique that measured the propagation time of the noiselike signal. In principle, the technique was the same as that used in sonar.

L. Adler (Ohio State Univ., US) discussed "Elastic Wave Scattering from Cavities and Cracks in Solids." Through spectrum analysis, considerable progress has been made in solving the "forward problem," the evaluation of the spectrum from scatterers of known shape and size. (Adler contends that the problem is essentially solved.) The present system is a broad-band pulsed arrangement involving digital spectrum analysis. A high-voltage spike with a fast rise time excites a 15-MHz immersion transducer. The pulser, connecting cable, and transducer are matched to produce a wide-band ultrasonic pulse that travels a 6.5-cm water path to a titanium disc having a void of known dimensions at the center. The scattered ultrasonic signal is received by a second transducer whose output electrical signal is amplified, digitized, and Fourier analyzed by a minicomputer. Reasonable agreement was demonstrated between experimental spectra and those calculated from scattering theory, which includes the Born approximation for values of $ka < 1$. Scattering from an elliptical crack in titanium produced a spectrum with a periodicity that was used to evaluate the crack dimensions. The "inverse problem," determination of the shape and size of a flaw from the scattered signal, was addressed only to the extent that the periodicity was indicated.

"Estimation of the Hole Volume and Energy of Creation of Holes in Liquids Using Acoustic Data" was presented by J. Glinski (Univ. of Wroclaw, Poland) and E. Soezkiewicz (Silesian Tech. Univ., Gliwice, Poland) on the basis of the hole theory of liquids. They concluded that the calculated hole volume agrees with other calculations only if the temperature dependence of the hole volume V_h is taken into account, and that the correlation coefficient between calculated and measured sound velocity is improved if the temperature dependence of V_h and of the energy of creation of holes e_h/V_h decreases with increasing values of V_h. In the author's opinion, the first two conclusions were to be expected; the third might be important to the development of a more detailed hole theory.

In "The Influence of Pressure on Mandelshtam-Brillouin Spectra of Kneser Liquids," B. Lezhnev, A. Seidov, and A. Shamov (Physico-Technical Institute, Ashhabad, USSR) pointed out that liquids such as tetraheptane that exhibit relaxation behavior show a marked pressure dependence of the ultrasonic wave velocity, a variation of approximately 12%, in the frequency range 2.5 to 9.4 GHz and temperature range 20 to 75°C.

J. Emery and S. Gasse (Faculté des Sciences, Le Mans, France) pointed out in "Ultrasonic Absorption and Dispersion in Liquids and Liquid Mixtures" that the Kramers-Kronig relation provides a good fit between theory and experiment on the relaxation region 2 to 200 MHz of the velocity of ultrasound over a dispersion step of the order of 2% in aqueous solutions of 30 and 35% of n-propanol and isopropanol.

In general, the papers presented during the course of the conference were interesting and informative. The meeting itself was worth attending because of the opportunity it presented to investigate research trends in acoustics and ultrasound in eastern European countries and the Soviet Union.

M. A. Breazeale

University of Tennessee
Knoxville, TN

MATHEMATICS

A. P. DAWID: APPLIED PHILOSOPHER

Statisticians who work primarily with applications, or with developing statistical theory to solve real-world problems, may sometimes view work on the philosophy and foundations of probability and statistics as too remote to be of much practical use. After all, one can go quite a long way in statistics without worrying much about questions such as, "What is probability?" and "Where do probability models come from?" The author recently had the pleasure of visiting Prof. A. Philip Dawid, who has returned to the Department of Statistical Science, University College, London after spending a few years at neighboring City University. Dawid's work spans a wide range of activities, from theoretical to applied.

An example of his applied work stems from his activities with the computer committee established by the Royal College of Physicians. This committee is concerned with the use of statistics in medicine and it establishes a forum for communication between the statistical and medical communities. Some of the issues the committee concerns itself with are the implementation and use of automated diagnoses, the accuracy of medical measurements, and the reliability of medical assessments. In the last-named context, Dawid has developed methods for estimating observer error rates. When a patient's history is taken by different clinicians, different replies may be obtained to the same question, due, perhaps, to slightly different wording or changes in the patient's attitude over a period of time. Similarly, in classifying a symptom for type, severity, extent, or duration, the patient and clinicians may have different interpretations of the underlying scale of measurement. It is well known that even a fairly low rate of error in recording such responses can lead to a considerable loss of diagnostic information. Dawid has developed a method for estimating the individual error rates of clinicians over multidimensional symptoms, even when the patient's "true" responses cannot be established.

Dawid's abilities shine brightest in his work on statistical foundations. Somewhat surprisingly (to some statisticians), such work usually has direct applications. Often it provides an elegant conceptual framework connecting seemingly disjointed statistical principles. A good example is his work with conditional independencies. Suppose X, Y, and Z are jointly distributed with density $p(x, y, z)$. The random variables X and Y are said to be conditionally independent, given Z (written $X \perp\!\!\!\perp Y|Z$) provided that for any value z of Z, $p(x, y|z) = a(x,z)\, b(y,z)$, or, equivalently, $p(x|y, z) = c(x,z)$.

The latter expression asserts that, when $X \perp\!\!\!\perp Y|Z$, the conditional distribution of X, given Y and Z, is completely determined by the value of Z alone; the value of Y is superfluous once Z is given.

Independence and conditional independence are familiar concepts of probability theory, where they form the bases of many areas such as Markov chains and limit theorems. Dawid argues that independence and conditional independence are equally fundamental in the theory of statistical inference. He has shown that many of the important concepts of statistics (such as sufficiency) can be regarded as expressions of conditional independence and that many results and theorems concerning these concepts are merely applications of simple general properties of conditional independence. Thus, he argues, by taking conditional independence as basic and expressing other properties in terms of it, one achieves a unification of many areas of statistics that appear at first sight to be entirely unrelated. Dawid says that conditional independence offers a new language for the expression of statistical concepts and a framework for their study.

Some elementary properties of conditional independence are:

(A) If $X \perp\!\!\!\perp Y|Z$, then $Y \perp\!\!\!\perp X|Z$;

(B) $X \perp\!\!\!\perp Y|Z$ if and only if $(X, Z) \perp\!\!\!\perp (Y, Z)|Z$;

(C) If $X \perp\!\!\!\perp Y|Z$ and $X \perp\!\!\!\perp W|(Y, Z)$, then $X \perp\!\!\!\perp (W, Y)|Z$; and

(D) If $X \perp\!\!\!\perp Y|Z$ and U is a function of X, then $U \perp\!\!\!\perp Y|Z$ and $X \perp\!\!\!\perp Y|(Z, U)$.

As an application of property (A), for example, consider the problem of operating a fair procedure for the selection of minority group members for university admission. One solution is to require that the probability of such selection should depend only on the academic promise of the candidate and not on race, sex, etc. Let X denote selection (X=1) or rejection (X=0), let Y denote (for example) sex, and let Z denote the score on a test used to measure academic promise. It is intended that $X \perp\!\!\!\perp Y|Z$. This could be monitored by checking whether $Y \perp\!\!\!\perp X|Z$, that is, by taking two test groups, one of successful and another of unsuccessful candidates, and determining whether the fractions of males getting any particular Z-score are the same in both groups.

One theme that runs through much of Dawid's work is the use of Bayesian models. In such terms, conditional independence can be used to express the sufficiency of a statistic T for a parameter θ that governs the distribution of a random variable X. Thus, if $X \perp\!\!\!\perp \theta|T$, then the conditional sampling distributions of X given T are the same for all values of the parameter, so T is sufficient for θ. Application of property (A) above to the case where θ has a prior distribution produces an important result in Bayesian inference: $\theta \perp\!\!\!\perp X|T$ means

that $p(\theta|x) = p(\theta|t)$, so the posterior based on the full data set is the same as that based only on a sufficient statistic.

Dawid and one of his PhD students, Mr. Guido Consonni, are working on alternatives to direct specification of prior distributions in Bayesian models. The approach is to introduce alternative structure into the model, from which the prior can be derived. The alternative structure may, at least in some cases, seem more natural to the statistician than does assumption of a prior. This alternative approach also seeks to clarify relationships between the distribution of X given θ and the prior distribution of θ. As an example, Consonni showed the author a situation in which assumptions of sufficiency of a certain type of function T of the observables (X's), exchangeability of the X's and the functional independence of T and the extreme order statistics ($X_{(1)}$ and $X_{(n)}$), together with some other minor conditions, imply that the distribution of the values is in the exponential family and the prior is the limiting distribution of the sufficient statistic.

D. R. Barr

ONR London

STATISTICAL COMPUTING AT ROTHAMSTED

Rothamsted Experimental Station, about 25 miles north of London, was one of the pioneer facilities in the world devoted to agricultural research through planned scientific experiments, and it continues to be a prestigious research facility. One of Rothamsted's strengths is the statistics department, consisting of 25 statisticians, a dozen of whom are active in research. A major thrust of the research is in experimental design in the tradition of F. Yates and the late Dr. Fisher, both associated with Rothamsted.

The head of the statistics department is Dr. John Nelder, whose research in linear models is well known. In a recent visit to Rothamsted, the author visited Nelder, John Gower, Rodger Payne, and Rosemary Bailey. Each is involved in significant research related to applications of interest to the Rothamsted mission. Gower is interested in practical procedures for reducing the dimensionality of statistical data and has done some recent work on the question, "When is a distance matrix Euclidean?" (A distance matrix is a symmetric matrix with non-negative entries and zero diagonal values. The question concerns whether the entries of such a matrix can be regarded as distances between points in a Euclidean space.)

Payne has been working on the problem of generating identification keys for determining the taxon of a specimen, given a vector of values of characters used for identification. Such problems arise in biological work (for example, identifying a yeast sample as being one of 439 yeasts, based on 78 characters), medical diagnoses, machine fault location, and computerized banking. An identification key may be viewed as a tree diagram with branch selections depending on the values of associated characters. The values might be determined as results of tests performed as needed in the identification process. With problems involving a large number of taxa and characters, the combinatorics of the situation can make the process of identifying the taxon of a specimen a nontrivial task. Payne has developed a computer program called GENKEY, which constructs identification keys for situations in which the characters can assume only a finite number of possible values. Several methods are available for constructing the keys, and various output forms, such as the conventional bracketed and indented as well as a diagrammatic form, can be selected by the user. The keys produced can be used sequentially, so the tests (determinations of values of the characters) are made one at a time. At each stage either the process terminates (with identification of the specimen) or the specific test to be applied next is indicated. This often permits identification with only a few tests, at a great savings in test effort.

Bailey (with H.D. Patterson at the University of Edinburgh) has developed a method for identifying confounded effects in quite general factorial designs; a dual process gives a method for constructing factorial designs with specified patterns of confounding. The constructing, which is done through the use of design keys, appears to be a very powerful tool in experimental design; a future article in ESN will be devoted to the topic.

Nelder's work in linear models has taken several directions. One area concerns the idea of marginality of effects in experimental design and the role of constraints among the parameters used to solve the normal equations. According to Nelder, many hypotheses that can be stated for a linear model and for which a corresponding sum of squares can be computed routinely, do not provide tests that are of practical interest. He believes that sums of squares that do not meet his marginality rules correspond to useless hypotheses. This typically includes a large fraction of the possible hypotheses in an analysis of variance.

A second area to which Nelder has contributed concerns generalized linear models. Linear models usually involve a (linear) systematic component and a random error component; the latter is often assumed to have a normal distribution. The analytic technique usually associated with the model is least squares. Techniques developed for non-normal data include probit analysis, in which a binomial variate has a parameter related to an underlying tolerance distribution, and contingency tables, in which the distribution is multinomial and the systematic part is usually modeled as being multiplicative. In both examples there is a linear aspect to the model: in probit analysis

the parameter p is a function of tolerance η which is itself linear on some function of dose level; in contingency tables with a multiplicative model, the logarithm of the expected relative frequency is assumed to be a linear function of the factors defining the table. In many such situations, a transformation is used to produce normal errors. This is different from the transformation of the expected values used to produce linearity.

Nelder has developed a unified approach to fitting such models based on a generalization of the maximum likelihood method used in probit analysis. The models considered are characterized by (1) a dependent variable whose distribution with parameter θ is one of the family

$$\pi(z;\theta,\phi) = exp[\alpha(\phi)\{z\theta - g(\theta) + h(z)\} + \beta(\phi,z)];$$

(2) a set of independent variables $x_1,\ldots,x_m$ and predicted $\eta=\Sigma\beta_i x_i$, where the β's are parameters, and (3) a linking function $\eta=g(\theta)$ connecting the parameter θ of the distribution of Z with the the linear model. The solution of the maximum likelihood equations is accomplished through an iterative weighted least squares procedure.

Nelder's approach gives a consistent way of linking the systematic elements with the random elements in a model. The ideas of analysis of variance can be extended by log-likelihood ratios to other distributions. This may produce an additive decomposition that can be used to fit the model sequentially. The approach simplifies the analysis of contingency tables by producing an additive decomposition of χ^2 when the table is partitioned.

The fact that a simple algorithm can be used to fit any of the models implies that a small set of routines can provide the basic computations necessary to fit models to a wide range of data. This has been done in the GLIM system. GLIM (General Linear Models) is a program developed by the Working Party on Statistical Computing of the Royal Statistical Society, to which Nelder and the Rothamsted group have made major contributions. It provides a framework for fitting generalized linear models to data, as well as other data input, analysis, and output-plotting functions. To use the model-fitting capabilities of GLIM, the user must specify the three components listed above in (1) to (3). The distribution associated with the response vector Z may be normal, poisson, gamma, or binomial. The link function g is expressed in the form $\eta=\Sigma\beta_i x_i=g(\mu)$, where $\mu=E(Z)$ may be any of the following eight functions:

$$\zeta=\mu,\ \eta=log\ \mu,\ \eta=1/\mu,\ \eta=\sqrt{\mu}$$

$$\eta=\mu^i,\ \eta=log\frac{p}{1-p}\ (logit),$$

$$\eta=\Phi(p)\ (probit),\ \eta=log\ (-log(1-p)).$$

The following are examples of situations that can be fitted and analyzed by the GLIM package: (1) linear models with factors and covariates and construction of analyses of variance (normal distribution and identity link), (2) fitting and testing log linear or linear models for discrete data including binomial or multinomial data and contingency tables with responses or factors (poisson distribution with identity link), (3) models for survival data based on the exponential distribution (gamma distribution and log link).

GLIM is a powerful package that is widely used in the UK. It is inexpensive (less than $400 for nonacademic sites and about half that for academic sites), and, because it consists of a single Fortran program of moderate size, it is easily portable. It should be useful to those who wish to use an interactive exploratory approach in their analyses.

Related packages with which the Rothamsted group has been involved are GENSTAT and PRISM. GENSTAT (GENeral STATistical program) is a package that includes many standard statistical analyses, has good features for data management, and can be programmed for user-specified analyses (Payne is responsible for the analysis of variance part of the package). GENSTAT shares with GLIM the advantages of low cost and easy portability. It is designed to be used mainly in a batch mode. PRISM is a package that combines the features of GLIM with a graphics capability. All three packages are distributed by the Numerical Algorithms Group Ltd, 7 Banbury Road, Oxford OX2 6NN, UK.

D. R. Barr

ONR London

NEWS AND NOTES

NEW OCEANOGRAPHIC ATLAS

The Ministry of Agriculture, Fisheries and Food (UK) has issued an "Atlas of the Seas Around the British Isles." Although both the editors, A.J. Lee and J.W. Ramster, are on the staff of the Ministry's Fisheries Laboratory at Lowestoft, the atlas covers a wide range of physical, chemical, biological, and geological variables that are crucial in almost any maritime activity in the region. Besides traditional shipping and fishery activities, the development of the North Sea oil field and the disposal of radioactive wastes into the Irish Sea are modern concerns to which the atlas is pertinent.

The physical, chemical, and biological background is dealt with in 27 subsections (which include • geological features such as bottom deposits, sand banks, sand waves and transport, and iceberg plough marks). Mean surface and bottom salinities and temperatures are given for both summer and winter, and

there are five subsections on tidal data. Plankton distributions, surface water movements, January wind roses, and 50-year wave heights and wave periods are covered. The results of the long-term monitoring of radionuclides are reflected in maps of the distribution of ^{137}caesium; distributions of zinc, nickel, copper, cadmium, reactive mercury, manganese, free phosphate (reactive or inorganic phosphate) and nitrate are also presented.

Fishing and spawning areas are mapped in 17 subsections, and sections deal with marine safety (lighthouses, light vessels, light buoys, meteorolical areas used in shipping forecasts, Decca navigation chains and lattice colors for "best fix" positions, and continental-shelf shipping clearance) and "other uses of the region." The latter section deals with mineral deposits, traffic flow, submarine telephone cables, ferry and merchant ship traffic, and the introduction of sewage and waste into the sea by both dumping and nondumping methods. Coastal towns with more than 50,000 people are located as are major ports and four major coastal industries (metal, shipbuilding, chemical and major offshore engineering construction centers).

The maps of each section are introduced by a brief essay by an expert on the subject covered or by the editors—there are some three dozen individual and corporate contributors.

The maps are clearly and colorfully printed and the sections are separated by dividers decorated with prints of original line and color wash figures from "The Piscatorial Atlas" published in 1883 by O.T. Olsen. The 12 x 16½ pages are spiral bound, making them easy to turn and to lie flat. The price is £12.90.

The atlas, copyright 1981, will serve well as a primary source of general scientific and industrial information; for other more detailed work it is intended only as a first line of reference, but it can be recommended as a very attractive and useful book.

F. A. Richards

ONR London

WORLD'S FASTEST CAMERA?

Researchers at Essex University, UK, are building a camera that they claim is the fastest photographic instrument in the world. Work on the device, which will be capable of taking 5 billion pictures a second, is being financed by a £75,000 ($150,000) grant from the UK Science and Engineering Research Council. Dr. Thomas Hall of the university's Physics Department is directing the effort.

The camera will be used to record pictures of fusion explosions achieved by powerful lasers compressing pellets of material such as hydrogen isotopes. The Essex researchers hope that the minutely detailed pictures of the explosions, which, they say, recreate the processes that fuel the sun, will lead them to a better understanding of the physics involved in fusion, and thus, ultimately, to the development of a new source of power.

Hall said that the process, which required extremely powerful lasers to achieve fusion, was feasible only if thin shells of material were used in the pellets; however, the thinness often produced instabilities in their reactions. By means of the camera, the researchers will seek to learn how the instabilities occur and how they can be eliminated.

A prototype of the camera has been built; the final version will be ready in about 18 months. The developers are aware that a camera capable of taking pictures at the same rate has been built in the US, but it is said to have technical problems.

D. J. Peters

ONR London

THE AMOUNT OF INFORMATION IN A QUESTIONNAIRE ITEM

Many items in mental tests and questionnaires are rather highly correlated, so a data set can often be represented by a collection of items that is considerably smaller than the original compilation. Beyond a certain point, a new item may add very little information. At the Organisme National de Securité Rontiére in France, T.B. Quoc has been using a simple information-theory approach to the selection and assembly of questionnaire items.

For each pair of items X and Y, Quoc computes H(Y|X), which is the conditional entropy of Y, given X:

$$H(Y|X) = -\sum_{i=1}^{I} p(X_i) \sum_{j=1}^{J} p(Y_j|X_i) \log p(Y_j|X_i).$$

If X and Y are statistically independent, then H(Y|X) will be equal to H(Y), the simple entropy of the variable Y (without information on X). But if X predicts Y perfectly, then H(Y|X) will be zero. The "Mutual Information" between Y and X can be expressed as a simple difference:

$$MI(X,Y) = H(X) - H(X|Y) = H(Y) - H(Y|X).$$

The relative "information earnings" from variable X over variable Y is then a simple ratio:

$$RI(X|Y) = \frac{MI(X,Y)}{H(Y)} = \frac{H(Y)-H(Y|X)}{H(Y)}.$$

To use this relative-information earnings concept in a questionnaire or test project, Quoc's procedure starts by calculating RI for all possible couples of items. The variable with the highest sum of relative information is then

identified. This is the first selected variable, and its row and column are removed from the matrix of variables. The process iterates, with the information earnings on the remaining sets of couples being computed, and so on. As the selection process continues, it is easy to calculate the cumulative percentage of information realized from any set of K selected variables. Usually, most of the information can be obtained from a much smaller set of the original item pool.

Quoc applied the information-earnings method to some results from a questionnaire study of TV spots. There were 58 items originally, but more than 95% of the information could be gained from only 10 items; the first 15 selected items contributed 99% of the information, and so there was much redundancy in the system. In a second study involving the analysis of 81 variables about road accidents, Quoc found that 40 items provided 90% of the information. Also, a principal components analysis of the 40 selected items produced the same factorial pattern as did the analysis on the larger set. The result suggests that the underlying structure can be robust over an item-selection routine based on abstract information concepts.

Quoc's method is not so elegant as some of the adaptive testing models, which can select item sets for each individual and can reduce test length by more than 70%. But it seems to be applicable to many survey situations where the analyst wants a simple and standard criterion for reducing the number of variables, and when many of the variables are moderately correlated with each other.

N. A. Bond, Jr.

ONR London

SUBJECTIVE PROBABILITY IN SPORT

Human subjects in probability experiments often seem to be rather poor information processors. They may radically overestimate or underestimate real probabilities; they may not combine probabilities and payoffs in the most optimal or efficient way; they may extract less information from a set of data than an "ideal" processor can realize from the same data; and so on. These limitations may be so pervasive and so serious that it often seems reasonable to "correct" human probabilistic outputs or to aid the judgments in various ways. It may be, though, that some of this alleged lack of capability is due to the fact that the subjects in probabilistic studies are naive in experimental situations. At a recent Festschript for Prof. John Cohen of Manchester University (UK), H.T.A. Whiting (Vakgroes Psychologie, Vrije Univeriteit, Amsterdam) previewed the probabilistic judgments made by skilled sportsmen.

The estimated fraction of successful football goals, from different distances, was extremely close to the actual likelihood of success (beyond 30 meters there is practically no chance of scoring); and professional players were better than amateurs. Another study looked into information used by novice and expert table tennis players; in table tennis a crucial output feature was the start time of the ballistic downswing. Non-trained players used both a displacement and velocity component, but experts mainly used displacement only. Perhaps the expert can use a simpler information basis and thus have a reduced processing load at crucial stages of the ball-return task. In earlier work with ball-catching, Whiting had shown that as a person becomes proficient at catching a ball, he progresses from an image-retina control system to an eye-head system.

Whiting's review not only emphasizes the necessity for using expert performers in probability-estimation studies, it suggests that personal conceptions of risk and achievement are also related to output and expectation probabilities in sports and in other uncertain situations. Maybe some of the intriguing questions about such events as sports "upsets" can be specified in such terms.

N. A. Bond, Jr.

ONR London

WAGE RATES AND INDUSTRIAL DECLINE

European basic industries such as steel, shipbuilding, basic chemicals, and textiles have been declining for some years, and there are many soft spots in autos and electronics. Some economists even argue that the members of the EEC are no longer industrial countries; in 1960, manufacturing and services in those countries had about equal shares in the total employment of people, but by 1979 the EEC service sector accounted for 53.4% of employed people, with manufacturing down to 28.8%. As the world demand for steel, chemicals, and textiles continues, it is obvious that these industries have moved out of Europe. Governments have seen the industrial decline as a threat and have taken various steps to support industry. British and Italian steel facilities are now nationalized, Italy and France sharply restrict Japanese cars entering the country, Germany and Denmark subsidize their shipyards, and so on.

The reasons for the European industrial decline are complex, but one cause is the disparity between wage rates in Europe and those in the newly industrialized countries. In the table below, the 1980 hourly earnings of a Belgian or German industrial worker are an order of magnitude above those paid in Taiwan and Korea. At the same time, European employers must operate under more regulations and restrictions than do their Asian counterparts.

Average Hourly Compensation
For Manufacturing Employees
(1980)

	U.S. Dollars
Belgium	13.18
Netherlands	12.18
Germany	11.94
France	9.46
Italy	9.01
Britain	7.07
Mexico	2.76
Brazil	1.73
Hong Kong	1.51
Taiwan	1.25
South Korea	1.10
Singapore	1.09

The mere fact that a national economy, or the general European economy, employs a higher proportion of people in services does not mean that such services are less productive than the dirty-hands industries. John Atkin, an economist at Citibank, London, points to the value of "tradable" services in a developed nation. Scientific, banking, insurance, and information services can be sold or traded abroad for basic industrial products, and in that sense they are just as basic as a shipment of chemicals or steel plate; in contrast, many government and social services can be consumed only in the home country and have no value outside the country. In this view, the thing for western governments to watch is not the percentage of services, but rather what percentage of these is tradable.

Analysis of trends in tradable service production leads to a more optimistic picture for European industry. That is because the fraction of European employment in tradable services has risen slowly but steadily for the last few years. Gradually, as the European scientific, financial, and information services make an impact on the newly industrial countries, those countries, too, will tend to move into higher technology industries. In such terms, the "decline" of European basic industry is an inevitable, and possibly desirable, consequence of a society's tendency to base its wealth less on heavy industry and more on information as the society develops.

N. A. Bond, Jr.

ONR London

SPLIT-BRAIN GAMING

For clinical purposes, as in treatment for severe epilepsy, the main connections between the left and right halves of the human brain may be severed. After the operation, the two sides can operate nearly independently. For instance, the left side of the brain receives visual signals from only the right half of the field of view. Having access to such an operated subject, Donald Mackay of Keele University (UK) recently set up a situation wherein the two halves of the brain played a game with each other. An interesting point was what would happen when the two sides of the brain were in conflict; would one hemisphere try to dominate, or would the two halves cooperate?

Mackay first showed the right-hand side of the brain a number between zero and nine (by flashing the number far to the left of where the subject was looking). Next the left hemisphere was required to guess the number orally. (The right side could hear the guess, but could not speak about its correctness). The right side, by using the left hand as a pointer, could point to instructions on a card. If the left-hemisphere guess was low, the left-hand pointed to an instruction to "go up," if too high, the left hand pointed to a "go down" instruction; when correct, the left hand pointed to "O.K." Eventually, the left-hemisphere-controlled speech centers will say the right number by following the instructions. The game can be played indefinitely, with the right side of the brain "knowing" the number and guiding the left side to a correct answer.

After some play in the above fashion, Mackay introduced a new feature into the game: the left hemisphere's hand had to pay for the guidance information received from the right hemisphere; at a cost of three tokens per bit of information, the left side of the brain rapidly goes broke. Now comes the question: would the right half of the brain settle for only two tokens per instruction, thereby giving the left half a longer run for its money? When faced with this conflict situation, the right indicated, again by pointing, that it would accept the reduced two-token payment, and at just that instant, the left stated orally, "Sure, make it two tokens." A final post-game statement from the subject must surely be one of the most poignant in experimental psychology: he said, "Are you guys trying to make two people out of me?"

Nicholas A. Bond, Jr.

ONR London

ONRL STAFF CHANGES

CDR Richard F. Ashford departed ONR London on March 14 to take up duties with the US Naval Sea Systems Command in Washington, DC. We wish CDR Ashford every success and happiness in his new assignment.

ONR CONSPONSORED CONFERENCES

ONR London can nonimate two registration-free participants in the conferences it supports. Readers

who are interested in such prticipation should contact the Chief Scientist, ONR London, as soon as possible.

Conference on Optical Techniques in Magnetic Resonance, Hull, UK, 31 March - 2 April 1982.

International Meeting on Lithium Batteries, Rome, Italy, 27-29 April 1982.

Symposium on Coastal Problems in the Mediterranean, Venice, Italy, 10-14 May 1982.

International Meeting on Analysis of Sample Survey Data & Sequential Analysis, Jerusalem, Israel, 14-18 June 1982.

NATO ASI on Numerical Taxonomy, Bad Windsheim, FRG, 4-16 July 1982.

1st Biennial National Atomic Spectroscopy Symposium, Sheffield, UK, 13-15 July 1982.

International Conference on Practical Bayesian Statistics, Cambridge, UK, 21-24 July 1982.

IXth IUPAC Symposium on Photochemistry, Univ. of Pau, France, 25-31 July 1982.

XI International Symposium on Mathematical Programming, Bonn, FRG, 23-27 August 1982.

4th Europhysical Topical Conference on Lattice Defects in Ionic Crystals, Dublin, Ireland, 30 August - 3 September 1982.

14th Europhysics Conference on Macromolecular Physics, "Polymer Crystals: Structure & Morphology," Vilafranca del Penedes, Spain, 21-24 September 1982.

EUROPEAN VISITORS TO THE US SUPPORTED BY ONR LONDON

Visitor	Affiliation	Navy Lab./Org. to be Visited
Dr. J.B. Abbiss	RAE Farnborough, UK	NRL, NSWC, USNA (20-21 April 1982)
Dr. L. Bengtsson	ECMWF, Reading, Berks, UK	NEPRF Monterey (June or July 1982)
Dr. J.C. Bennett	Dept. of Electronics and Elec. Engr., Univ. of Sheffield, UK	NOSC, San Diego (March or April 1982)
Dr. John Nelder	Rothamsted Experimental Station, Harpenden, Herts, UK	ONR (4 May 1982)
Dr. C. Ranz & Dra. A. Soler	Instituto de Acustica, Madrid, Spain	ONR, NRL, NUSC or NORDA (19-22 April 1982)

ONRL REPORTS

C-12-81 The Biological Effects of Nonionizing Radiation, by J. B. Bateman

This is a critical report on the L.H. Gray Memorial Conference held in Oxford, 13-16 July 1981. The Conference was entitled "Biological Action of Radiofrequency, Microwave and Ultrasonic Radiations." The report provides a background identifying the field of interest in broader terms, intended for the general reader. It is then pointed out that the conference was mainly directed toward research and practice related to the possible value of non-ionizing radiations in cancer therapy. There were, however, tutorial lectures of a fairly general character and some discussion of biological effects not necessarily arising from production of heat in irradiated tissues.


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